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CERTIFICATE

This certificate is issued in support of an application for Patent registration in a country outside New Zealand pursuant to the Patents Act 1953 and the Regulations thereunder.

I hereby certify that annexed is a true copy of the Provisional Specification as filed on 16 September 2004 with an application for Letters Patent number 535351 made by Graydon Aubrey Shepherd.

Dated 13 December 2004.

PRIORITY DOCUMENT
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535351

NEW ZEALAND

Patents Act 1953

PROVISIONAL SPECIFICATION

Title: Engine

I, ***Shepherd, Graydon Aubrey***,
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Address: *37 Huntingtree Avenue, Sandringham, Auckland, New Zealand,*

do hereby declare this invention to be described in the following statement :

Reciprocating Engine

FIELD OF THE INVENTION

This invention relates to a reciprocating engine, and in particular, but not exclusively to a reciprocating engine using diesel or petroleum as a fuel source.

BACKGROUND

Since the industrial revolution a number of reciprocating engines have been developed, each one having advantages or improvements over previous models.

The fossil fuel reciprocating engines have largely used a two or a four stroke cycle. The two stroke cycle engines having the advantage of one power stroke per revolution, as opposed to one power stroke for every two revolutions in the four stroke cycle. However, the two stroke cycle engines have two distinct disadvantages. The first being that their breathing is not always efficient, some unburnt fuel and/or oxygen is lost to the exhaust system, and some exhaust gases remain after the exhaust cycle. And secondly, two stroke engines require oil to be added to the fuel to effect lubrication of the crank shaft and piston. Both of these factors mean that two stroke engines produce high levels of pollution.

A further problem with present technology engines is the conversion of forces felt by the piston into rotary motion. This is traditionally performed using a crank shaft. However, a crankshaft is most efficient when the crank arm is at right angles to the direction of motion of the piston, but is very inefficient at other angles. And the largest forces are felt on the piston around top dead centre, when the crank arm is almost aligned with the direction of motion of the piston, resulting in very inefficient transfer of forces into the crank arm.

OBJECT

It is therefore an object of the present invention to provide a reciprocating engine which will at least go some way towards overcoming the above mentioned problems, or at least provide the public with a useful choice.

STATEMENTS OF THE INVENTION

Accordingly, in a first aspect, the invention may broadly be said to consist in a reciprocating engine operating on the two stroke cycle, comprising;

> a pair of stationary concentrically aligned mutually opposed pistons separated by a sleeve adapted to reciprocate between the pistons, the reciprocating sleeve defining two cavities, each cavity being operatively connected to one of the pistons to define a chamber, the first chamber being a pre-charge chamber and having at least one valved inlet port, and the second chamber being a combustion chamber and having at least one valved outlet port, the two chambers being separated by a transfer valve.

Those skilled in the art will appreciate the advantages of this reciprocating engine. The stationary pistons allow for lubrication of the piston rings by way of internal oil-ways, eliminating the need to add fuel to the oil. Also, the engine design does not require the use of a crank shaft to convert the reciprocating motion into rotary motion. Other arrangements such as a cam roller fitted to the reciprocating sleeve, and a rotating sleeve having a cam profile can be used.

Preferably the engine includes at least two reciprocating sleeves, and more preferably each pair of reciprocating sleeves operate in mutually opposing directions. Such an arrangement can provide improved engine balancing.

Preferably the engine uses diesel fuel, but clearly any type of fuel can be used, and a spark plug can be used for ignition.

Preferably the conversion of reciprocating motion to rotary motion is accomplished by the use of a cam roller which is caused to move by the reciprocating sleeve, the cam roller being in communication with a cam profile on one end of a rotatable sleeve.

Preferably the rotating sleeve has a multi-apex cam profile such that it takes more than one complete cycle of the reciprocating sleeve to produce one revolution of the rotating sleeve. In some cases it may be advantage to have a slow revolving engine that takes for example 12 cycles of the reciprocating sleeve to produce one revolution of the rotating sleeve.

Preferably each of the inlet and outlet ports use their associated piston to effect the opening and closing of the ports. However, other valve arrangements can be used, for example a cam shaft operated valve to provide more flexibility of valve timing.

DESCRIPTION

The invention may also broadly be said to consist in the parts, elements and features referred to or indicated in the specification of the application, individually or collectively, and any or all combinations of any two or more of the parts, elements or features, and where specific integers are mentioned herein which have known equivalents, such equivalents are incorporated herein as if they were individually set forth.

A number of preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawings in which,

FIGURE 1 is a schematic diagram showing the operation of the reciprocating engine cycle with the combustion chamber in the compression phase,

FIGURE 2 is a schematic diagram showing the operation of the reciprocating engine cycle with the combustion chamber continuing in the compression phase, and air beginning to enter the pre-charge chamber,

FIGURE 3 is a schematic diagram showing the operation of the reciprocating engine cycle at the stage where fuel is introduced and ignition occurs, and the power stroke begins,

FIGURE 4 is a schematic diagram showing the operation of the reciprocating engine cycle towards the end of the power stroke and when the exhaust gases begin to exit the combustion chamber,

FIGURE 5 is a schematic diagram showing the operation of the reciprocating engine cycle at the point at which the inlet valve opens to allow a charge of fresh air to transfer from the pre-charge chamber to the combustion chamber, and to complete the purging of the exhaust gases,

FIGURE 6 is a schematic diagram showing the operation of the reciprocating engine cycle at the stage where the inlet valve closes and the reciprocating sleeve changes direction to begin the compression stroke,

FIGURE 7 is a schematic diagram of the reciprocating engine showing the conversion of the reciprocating motion of the reciprocating sleeve into rotary motion using a crank shaft,

FIGURE 8 is a schematic diagram of the reciprocating engine showing the conversion of the reciprocating motion of the cylinder sleeve into rotary motion using a roller which causes a sleeve having a cam profile to rotate,

FIGURE 9 is a cross sectional view of an opposed twin reciprocating sleeve engine,

FIGURE 10 is a cross section perspective view of the opposed twin reciprocating sleeve engine,

FIGURES 11 to 15 are perspective views progressively showing the build up of the opposed twin reciprocating sleeve engine,

FIGURE 16 is a schematic view of the engine in a marine application, and

FIGURE 17 is a perspective view of a gearing arrangement which can be used to alter the output drive-shaft speed.

FIGURE 18 is a schematic perspective view of an engine assembly incorporating a number of individual opposed twin reciprocating sleeve engine units.

With reference to **Figure 1,** a reciprocating engine (10) is shown comprising at least a reciprocating sleeve (11), a first piston (13) and a second piston (15). The reciprocating sleeve (11) comprises two cylindrical portions, each of which can have a different diameter as shown, and these two cylindrical portions are separated by an intermediate bulkhead (16).

The reciprocating sleeve (11) is shown moving in a compression stroke direction (17), and is causing the gases in a combustion chamber (19) to be compressed. A partial vacuum is being created in a pre-charge chamber (21).

A transfer valve (23) is used to control the flow of gases through a passage (24) in the intermediate bulkhead (16). The transfer valve (23) is a one way valve, and while not shown, is biased closed by a light spring. At the stage of the operating cycle of the engine (10) shown, the transfer valve (23) is closed.

The figures 2 to 6 continue from figure 1 to show one complete cycle of the reciprocating engine (10).

With reference to **Figure 2,** the engine (10) is shown with the reciprocating sleeve (11) continuing to move in the compression stroke direction (17). The gases in the combustion chamber (19) are continuing to be compressed. At this stage, an inlet port (25) is no longer covered by the second piston (15) and air is able to be drawn in a direction (27) into the pre-charge chamber (21).

With reference to **Figure 3**, the engine (10) is shown with the reciprocating sleeve (11) reaching the extent of it's travel in the compression stroke direction (17), and beginning to move in the opposite direction, represented as a power stroke direction (29). At this point the gases in the combustion chamber (19) are fully compressed. Diesel fuel (31) is injected into the combustion chamber (19) and self ignites due to the pressure within the cylinder. The burning fuel and compressed gases expand to push against the intermediate bulkhead (16) and to move the reciprocating sleeve (11) in the power stroke direction (29).

With reference to **Figure 4**, the engine (10) is shown with the reciprocating sleeve (11) moving in the power stroke direction (29) and completing the power stroke. The gases in the combustion chamber (19) are completing their combustion and expansion. The exhaust port (35) is no longer fully covered by the first piston (13), and is allowing the burnt or exhaust gases to escape in a direction (37).

The pre-charge gases in the pre-charge chamber (21) are being compressed, the inlet port (25) now being covered by the second piston (15).

With reference to **Figure 5**, the engine (10) is shown with the reciprocating sleeve (11) having moved a little further in the power stroke direction (29). At this stage a significant proportion of the burnt gases have left the combustion chamber (19). The pressure within the pre-charge chamber (21) is now greater than the pressure within the combustion chamber

(19), causing the transfer valve (23) to move in a direction (39) and to open the passage (24). This allows the compressed gases in the pre-charge chamber (21) to move in a direction (41) and to begin purging the combustion chamber (19).

It can be an advantage to have the diameter of the pre-charge chamber (21) greater than that of the combustion chamber (19) as this gives the opportunity to provide improved purging of the combustion chamber (19).

With reference to **Figure 6**, the engine (10) is shown with the reciprocating sleeve (11) reaching the full extent of it's movement in the power stroke direction (29), and beginning to move again in the compression stroke direction (17). When the gases have largely transferred out of the pre-charge chamber (21) and into the combustion chamber (19), the transfer valve (23) will move in a direction (41) to close.

The cycle then continues as described above with reference to figure 1, and so on.

With reference to **Figure 7**, a more complete example of the reciprocating engine (10) is shown. In this example the reciprocating sleeve (11) is shown connected via a short pin (43) to a connecting rod (45) which is in turn connected to a crank shaft (47). The crankshaft (47) is supported on bearings (49), and has a flywheel (51) mounted on it.

The reciprocating motion (53) is converted into rotary motion (55). Some of the energy transferred into the flywheel (51) during the power stroke is used in turn to move the reciprocating sleeve (11) during the compression stroke, allowing the cycles of the engine to be continued. Clearly the crankshaft (47) could also include an output shaft or a drive surface.

With reference to **Figure 8**, another example of a more complete reciprocating engine is shown. In this case the crank shaft is replaced by a rotating sleeve (57), having a cam profile (59) on one end. A roller (61) is supported on a pin (63) which is attached to the reciprocating sleeve (11). As the reciprocating sleeve (11) moves in the power stroke direction (17), the roller (61) causes the rotating sleeve (57) to rotate, as the roller (61) acts against the cam profile (59).

As the rotating sleeve (57) rotates, energy is transferred into a flywheel (65). Stored energy within the flywheel (65) causes the rotating sleeve (57) to continue to rotate and in turn the continuation of the cam profile (67) moves the roller (61) in the direction opposite to the direction (17). This action causes the reciprocating sleeve (11) to move in the compression stroke direction (29). The configuration as shown in this figure has the advantage that it has two power strokes per revolution of the rotating sleeve (57). Different cam profiles having more than 2 lobes can be used to provide more than two power strokes per revolution.

In this example the rotating sleeve (57) is mounted on a set of bearings (69). Clearly the rotating sleeve (57) could also include an output shaft or a drive surface.

In both figures 7 and 8 the first and second pistons (13) and (15) and the bearings (49) and (69) are shown as being fixed relative to one another, by the use of a symbol (71) as illustrated in these figures.

Figures **9** to **15** show an opposed twin reciprocating sleeve engine (73) which incorporates a pair of assemblies substantially as outlined with reference to figure 8, but having a single rotating sleeve with a cam profile at each end.

With reference to both **Figures 9** and **10** the opposed twin reciprocating sleeve engine (73) is shown in cross section. This opposed twin reciprocating sleeve engine (73) has two reciprocating sleeves (11), two first pistons (13) and two second pistons (15), and each set of these is arranged in line and in an opposing manner. The opposing operation is intended to reduce vibration or to improve the balance of the engine (73) when operating.

The engine (73) is given structure or support by the use of a static sleeve (75). The reciprocating sleeves (11) operate within the static sleeve (75) and the rotating sleeve (57a and 57b) operates about the static sleeve (75) and is supported by the bearings (69). In this case the rotating sleeve (57a and 57b) is manufactured in two portions, the inner portion (57b) having cam profiles at each end, and the outer portion (57a) being adapted to mate with the outer races of the bearings (69). The first and second pistons (13 and 15) are held fixed within the static sleeve (75). A screw (75a) secures the second piston (15) to the static sleeve (75).

It can be seen that the two pistons (15) are formed by different constructions between figure 9 and figure 10, however these changes are simply manufacturing variations and do not affect the operation of the engine (73). Similarly figure 10 shows the use of a bearing retaining ring (69a) which is not used in figure 9.

Inlet air enters the inlet chamber (21) via the inlet port (25) which is in communication with the two ports (25a and 25b).

The exhaust gases are able to escape through an exhaust passage (77) into an exhaust intermediate chamber (79). The pressure within the exhaust gases at this time can assist in pushing on the reciprocating sleeve (11) during their exit. The exhaust gases then pass through an intermediate exhaust port (81) and into a final chamber (83) before exiting out a final exhaust port (85).

A diesel injector (87) is provided to inject diesel directly into the combustion chamber (19) when required.

As with the engine (10) shown in figure 8 a roller (61) is supported on each reciprocating sleeve (11) by a pin (63). During the power stroke of the engine (73) the reciprocating sleeves (11) act to push the rollers (61) against the cam profiles on each end of the inner portion of the rotating sleeve (57b), causing the rotating sleeve (57a and 57b) to rotate. Momentum in the rotating sleeve (57a and 57b) and in any flywheel to which it may be coupled, cause the rotating sleeve (57a and 57b) to continue to rotate and the interaction of the cam profiles with the rollers (61) then causes the reciprocating sleeves (11) to move in a compression stroke direction (17). This operating cycle is the same as that described with reference to figures 1 to 6 above, but in this case is occurring in the opposing twin reciprocating sleeves simultaneously, but in opposite directions.

Figures 11 to 15 show a progressive build-up of the opposed twin reciprocating sleeve engine (73) by way of further explanation.

With reference to **Figure 11** the first and second pistons (13 and (15) are shown correctly orientated, as are the rollers (61) and the pins (63). The first pistons are also shown incorporating a final exhaust chamber end fitting (83a).

With reference to **Figure 12** the reciprocating sleeves (11) are shown fitted about the pistons (13 and 15).

With reference to **Figure 13** the static sleeve (75) is shown fitted, as are the bearings (69) and the bearing retaining rings (69a).

With reference to **Figure 14** the inner portion of the rotating sleeve (57b) is shown installed. In this view the cam at each end of the sleeve (57b) are clearly shown.

With reference to **Figure 15** the outer portion of the rotating sleeve (57a) is shown installed and mated with the bearing retaining rings (69a).

With reference to **Figure 16** the engine assembly (10) is shown fitted for example to a boat (89). In this example the engine assembly is fitted to an engine mount fitting (91) mounted on a bulkhead within the boat. A coupling (93) connects the rotating sleeve (57) to the propeller shaft (95) of the boat (89). It can be seen that such an arrangement provides a compact in-line marine engine configuration.

With reference to **Figure 17** the engine assembly (10) is shown coupled with a gearing system. In this example the rotating sleeve (57), or an extension of it, is causing three planetary gears (101) to orbit within a fixed ring gear (103), the planetary gears (101) also being engaged to a sun gear (105) which is fixed to one end of an output shaft (107). The fixed ring gear (103) is shown partially cut way. Such an arrangement can be used to provide a compact step-up gearing system that can be used to increase the output shaft (107) speed over the engine operating speed. In a case where the engine assembly (10) has a large number of cam profiles on the rotating sleeve (57), and has many power strokes per revolution, a step-up gearing system would be advantageous is some applications.

With reference to **Figure 18** an engine assembly (150) having four reciprocating sleeve engines (73), as described above, situated about an output shaft (151) is shown in a schematic drawing. A gear wheel (153) is mounted on the rotating sleeve (57) of each engine (73) and is driven by the rotating sleeve (57). Each gear wheel (153) engages with an output gearwheel (155) which is attached to the output shaft (151). In this way, the four engines (73) combine to drive the output shaft (151).

The individual engines (73) are mounted on a support structure (157) to make up the engine assembly (150). While the support structure (157) is illustrated using a network of struts in this example, the individual engines (73) could alternatively be supported within a cylindrical support structure, which in turn could be mounted to the structure of a ship, or any manner of other supporting structures.

This example shows an engine assembly (150) having four individual engines (73), but it is envisaged that any number of engines (73) could be used, depending on the space about the output gearwheel (155) and the number of output gearwheels (155). While the example shown has four equally spaced engines (73), it is envisaged that the engines (73) could be spaced apart or grouped to suit any particular installation requirements.

Such an engine assembly (150) could be used as a marine engine in a ship, to drive a propeller (159). The advantage of such an engine configuration is that a large number of power strokes can be made for each single revolution of the propeller (159). For example, if each engine (73) had a 12 lobe cam profile on their respective rotating sleeves, and there was a six to one reduction gearing ratio between each gear wheel (153) and the output gearwheel (155), the engine could produce 576 power strokes per revolution of the engine. The figure of 576 is calculated as follows: 12 lobes means 24 power strokes per revolution of each engine (73), this 24 power strokes is multiplied by 4 since there are 4 engines (73) in the complete engine assembly (150) giving 96 power strokes, and the 6:1 reduction gearing means 6 x 96, or 576 power strokes per single revolution of the propeller (159). In a marine engine situation where it is important to provide a very large power input to a propeller, but where it is important to do so at a very low rotational speed, such an engine assembly (150) would be advantageous. The use of such an engine assembly could eliminate or reduce the need for a reduction gearbox in a marine drive system.

This engine assembly (150) adds the power output from a number of combustion cylinders in a parallel manner, as opposed to a series addition which is used in a multi-cylinder in-line engine. That is, in an in-line engine, each cylinder adds torque to a single crankshaft. The crankshaft at the output end of the engine must carry all of the combined torque from each of the cylinders, requiring a large and heavy crankshaft if the engine has a large number of combustion cylinders. If more power is required and additional combustion cylinders are

added, the crankshaft torque requirements become even greater. In contrast, using an engine assembly (150) design as described herein, the power output can be increased by providing addition engines (73) about the output gearwheel (155), and while the output gearwheel (155) must be designed to cope with the increased torque, the components of each individual engine (73) does not need to be strengthened in any way. Such an engine assembly (150) can therefore achieve size and weight savings as compared to a conventional in-line engine.

Another advantage of the engine assembly (150) is that individual engines (73) can be removed and/or replaced as required for maintenance purposes. This gives greater flexibility in the manner that the engine assembly (150) is used and maintained when compared to conventional in-line engines.

VARIATIONS

While the engine in the examples uses diesel fuel, other fuels such as any hydrocarbon fuel or hydrogen could be used, and an ignition plug could be added to the crown of the first piston to provide ignition if required.

The examples describe an engine having a single or a double reciprocating sleeve, but clearly any number of sleeve assemblies can be incorporated into a single engine assembly.

DEFINITIONS

Throughout this specification the word "comprise" and variations of that word, such as "comprises" and "comprising", are not intended to exclude other additives, components, integers or steps.

ADVANTAGES

Thus it can be seen that at least the preferred form of the invention provides a reciprocating engine which operates with a two stroke cycle, but does not require oil to be mixed in with the fuel for engine lubrication.

Also, the reciprocating engine has improved breathing over traditional two stroke engines, and more efficient purging of the exhaust gases can be achieved.

And, in addition, the method by which the reciprocating motion is converted into rotary motion, by the use of a rotating sleeve having a cam profile on one end, allows greater flexibility in the way in which power is extracted during the power stroke. That is, the cam profile can be optimised so that the forces produced by the sleeve during the power stroke can be most efficiently turned into rotary motion. The conversion of reciprocating motion into rotary motion is no longer constrained by mechanical linkage to the circular motion of a crank shaft.

PIPERS
Attorneys for:
Graydon Aubrey Shepherd

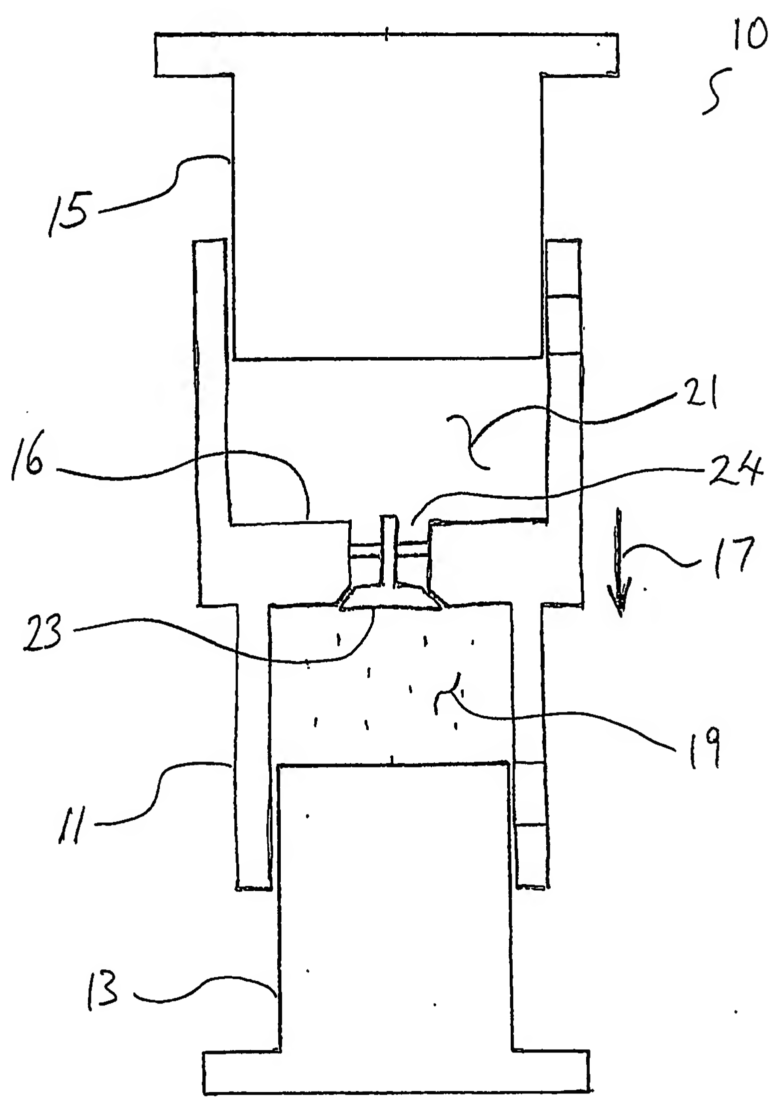


FIG 1

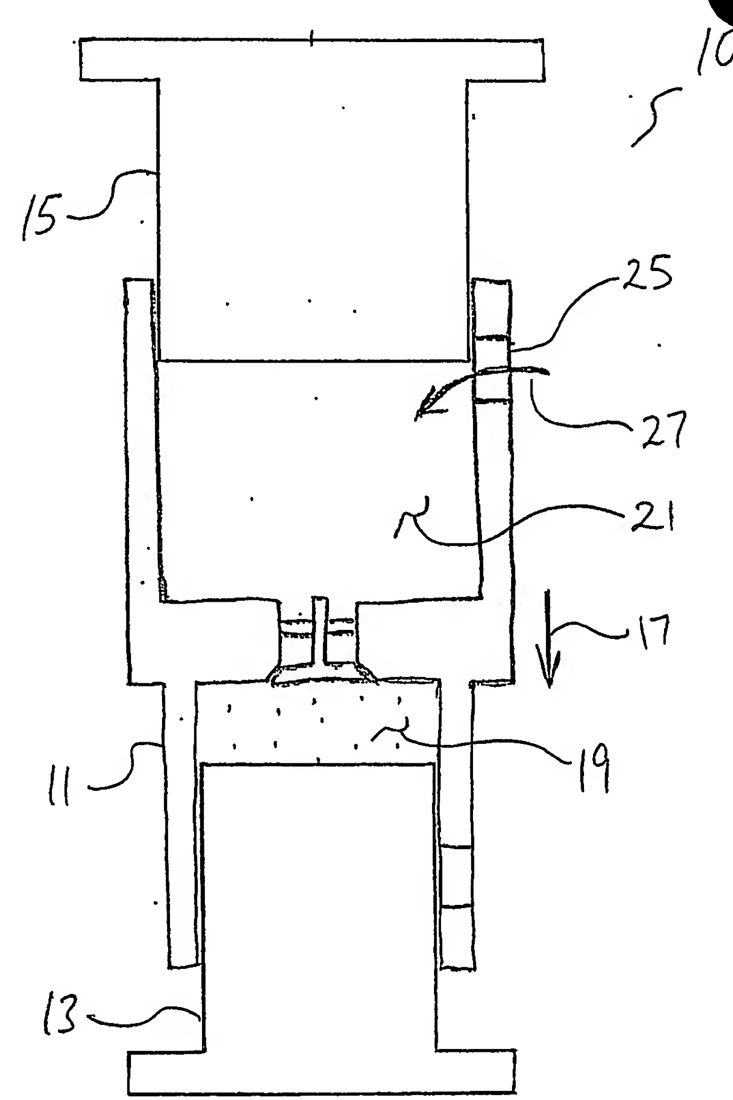


FIG 2

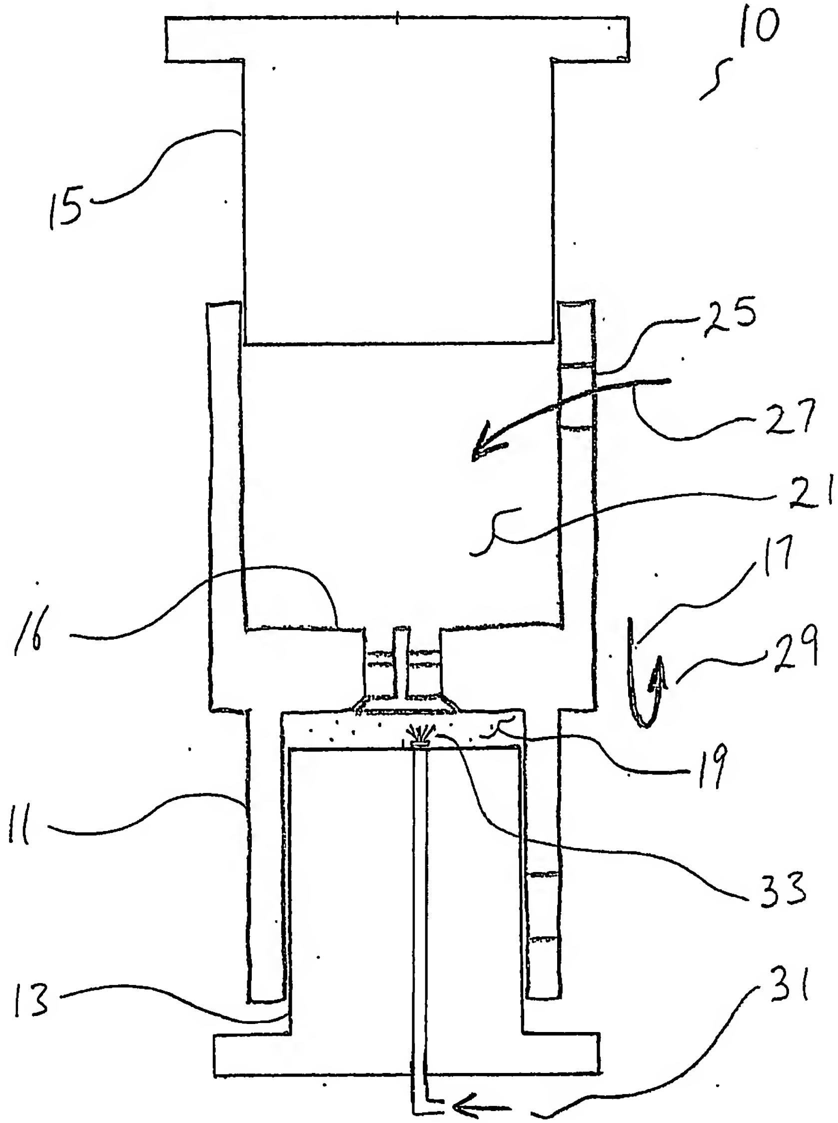


FIG 3

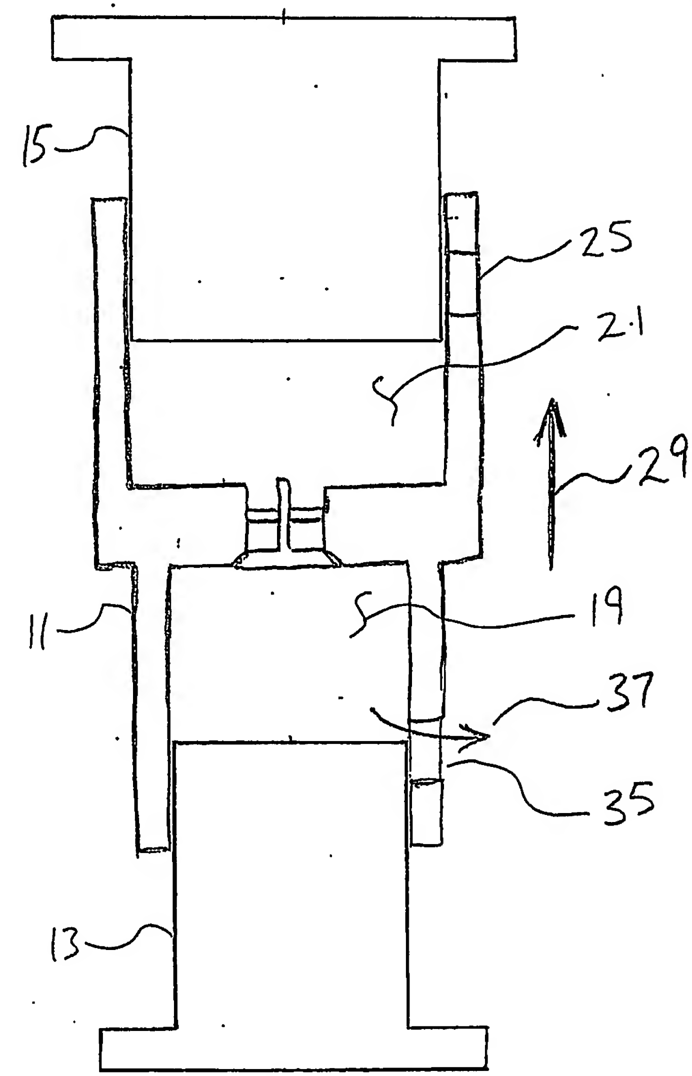


FIG 4

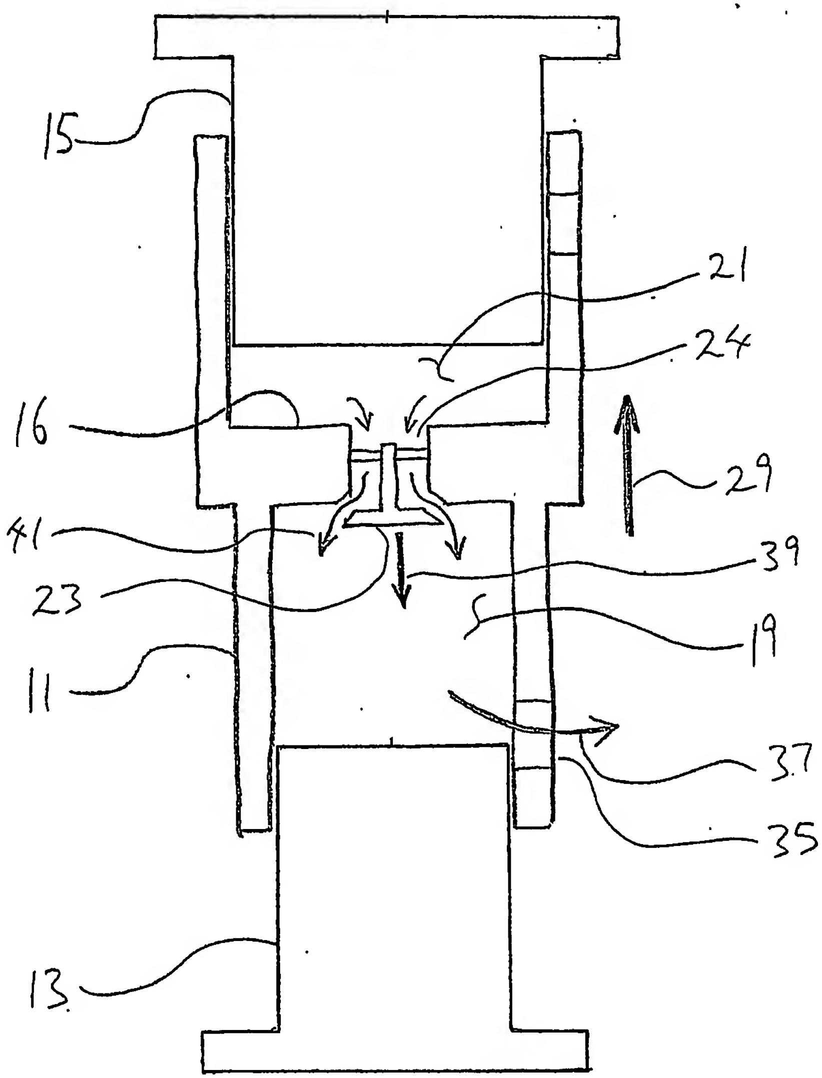


FIG 5

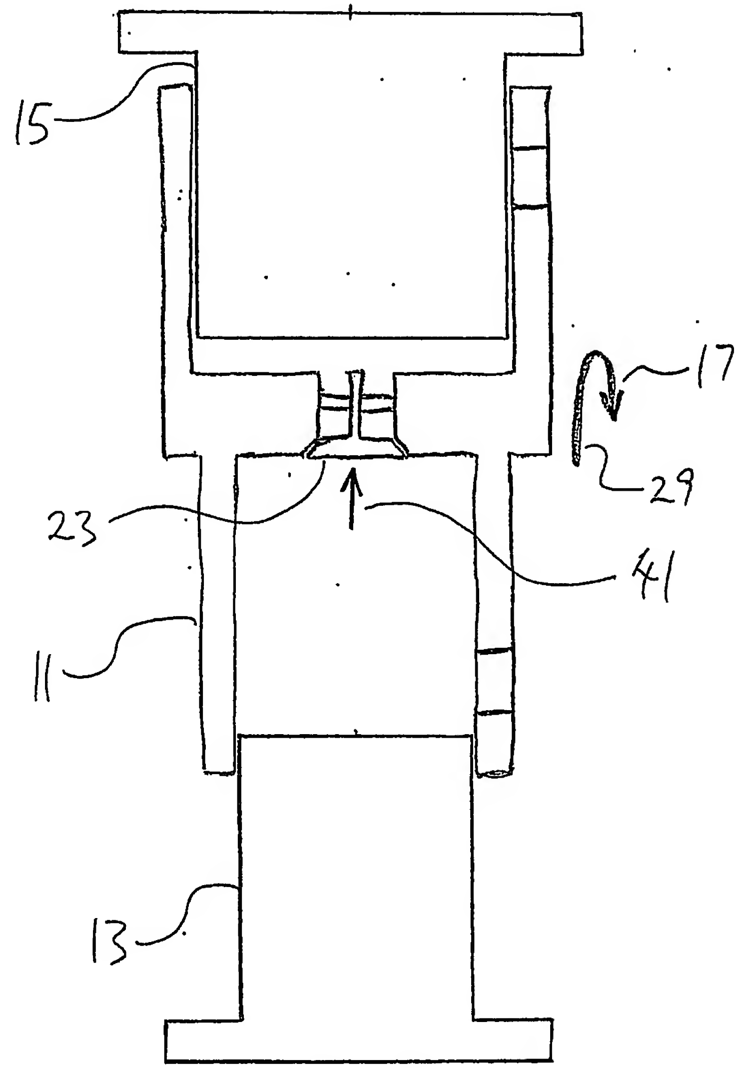
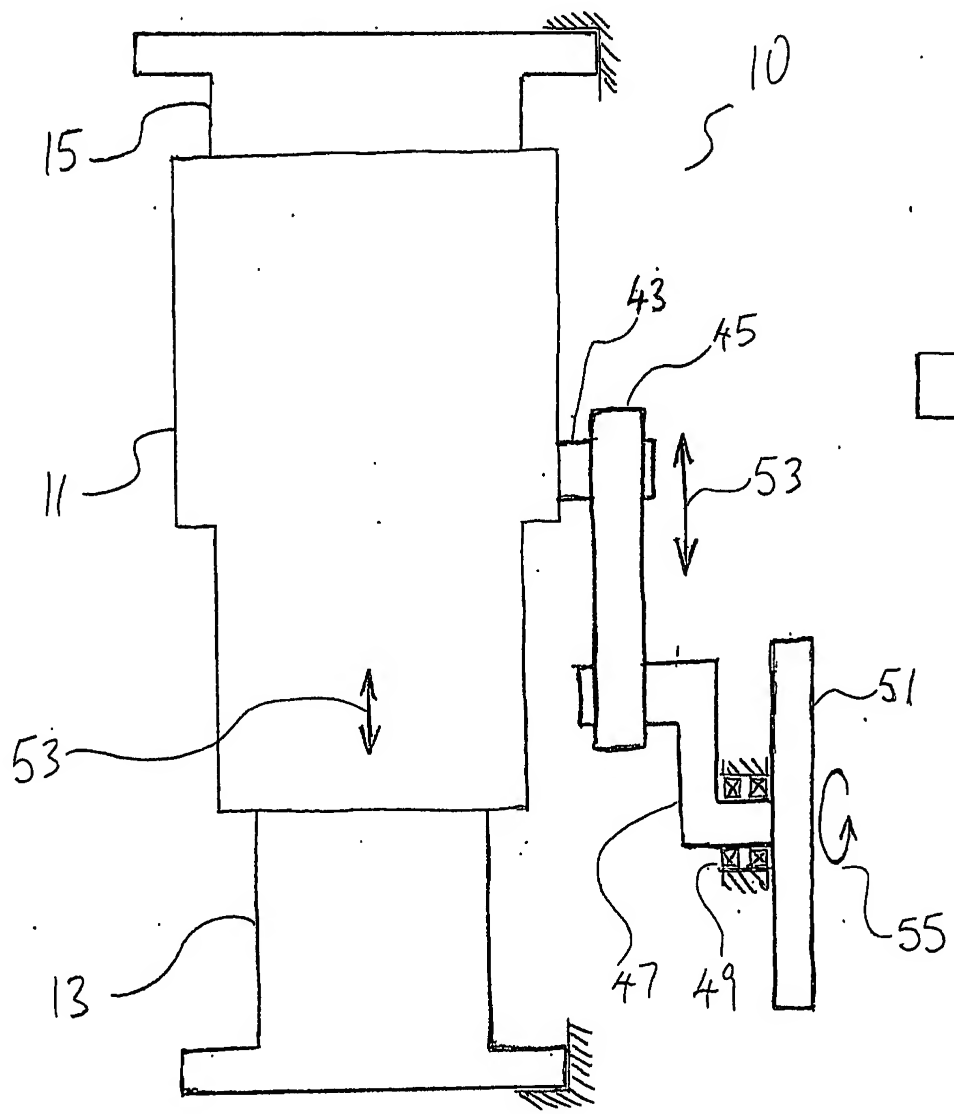
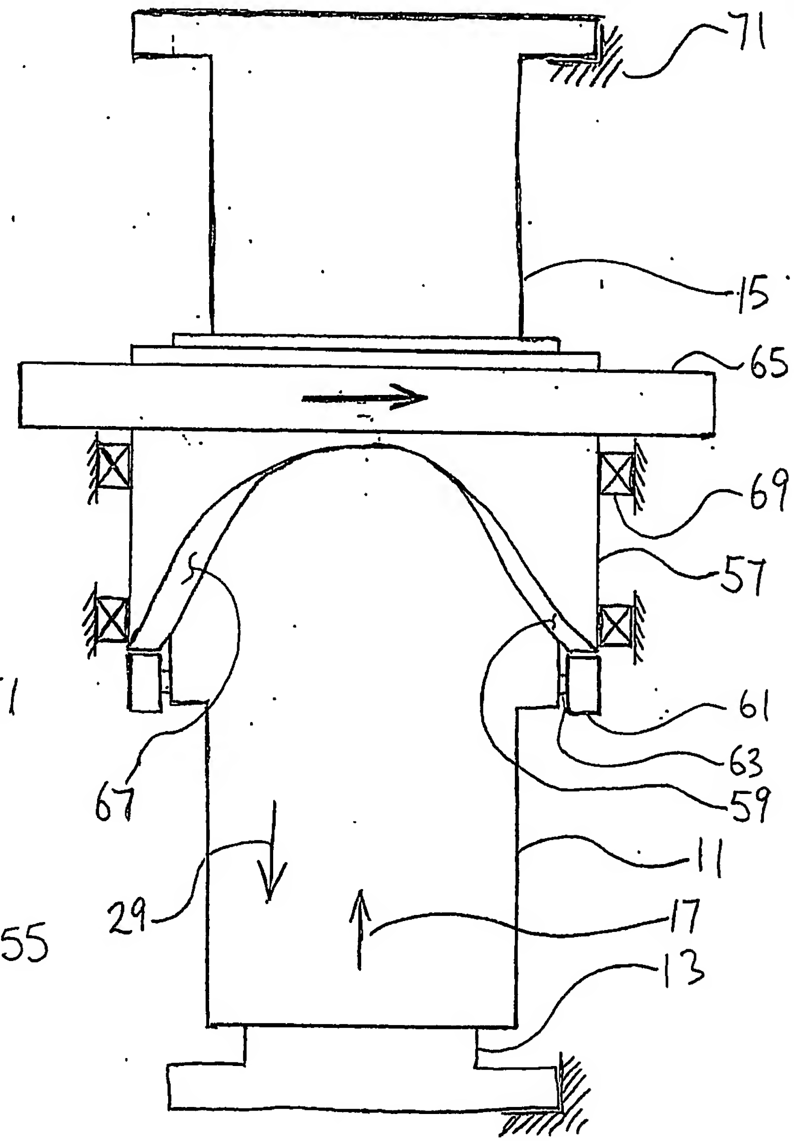


FIG 6



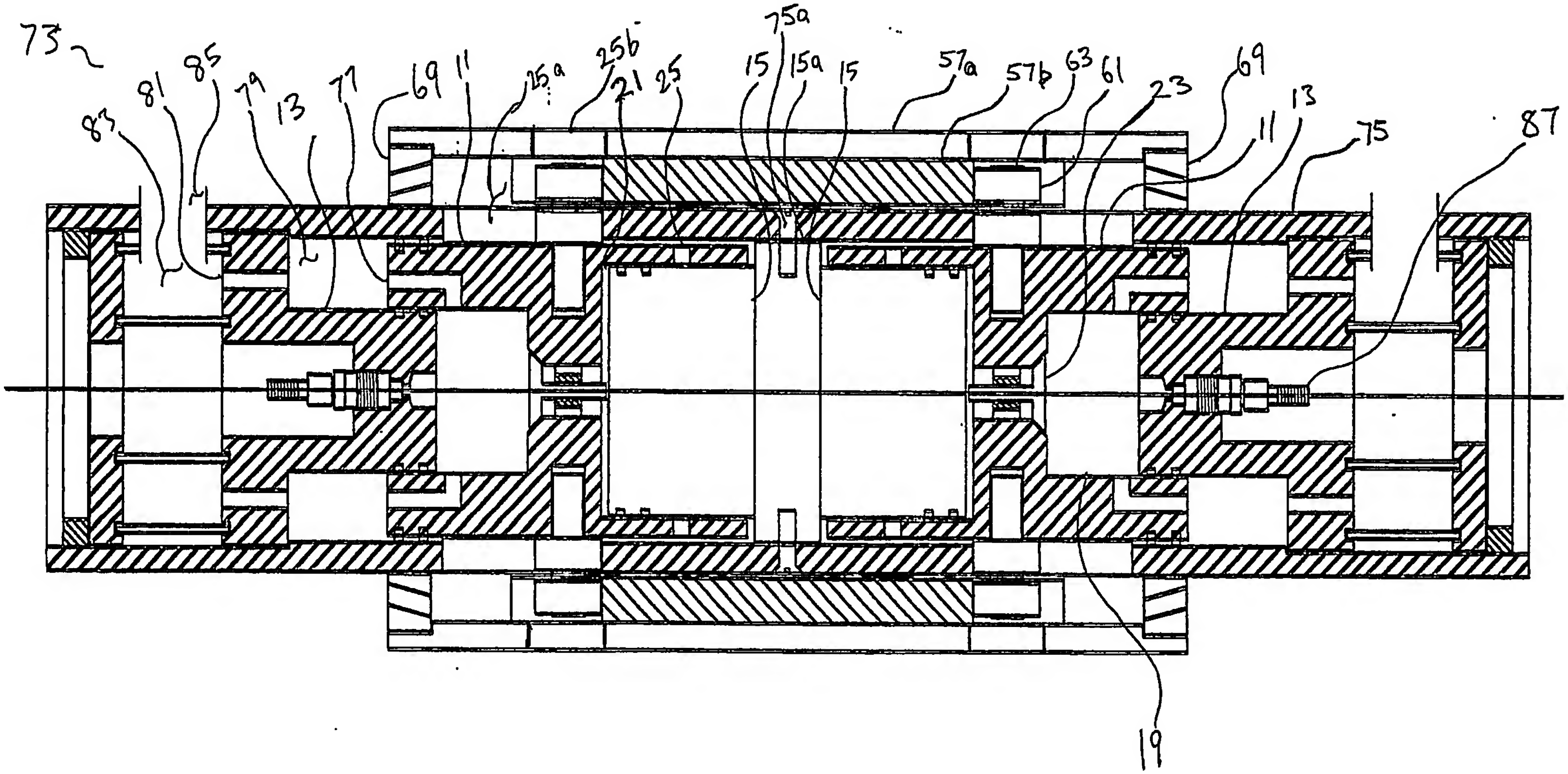
10
15
11
53
13
43
45
53
51
47
49
55

FIG 7.



71
15
65
69
57
61
63
59
67
11
29
17
13

FIG 8



73
83
81
85
79
13
77
69
11
25a
25b
21
25
75a
15
15a
15
57a
57b
63
61
23
69
11
13
75
87
19

FIG 9

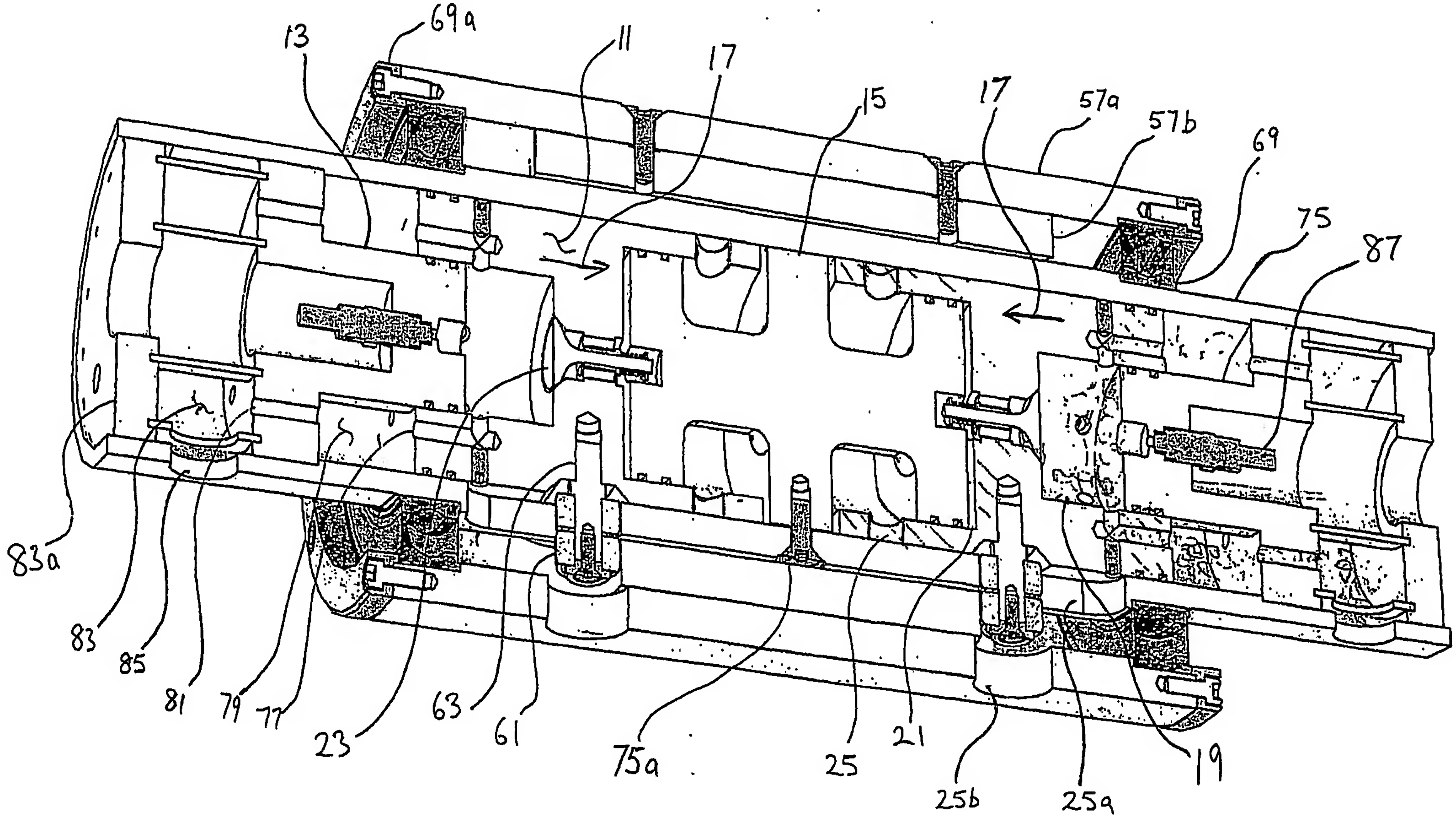

69a
13
11
17
15
17
57a
57b
69
75
87
83a
83
85
81
79
77
23
63
61
75a
25
21
25b
25a
19

FIG 10

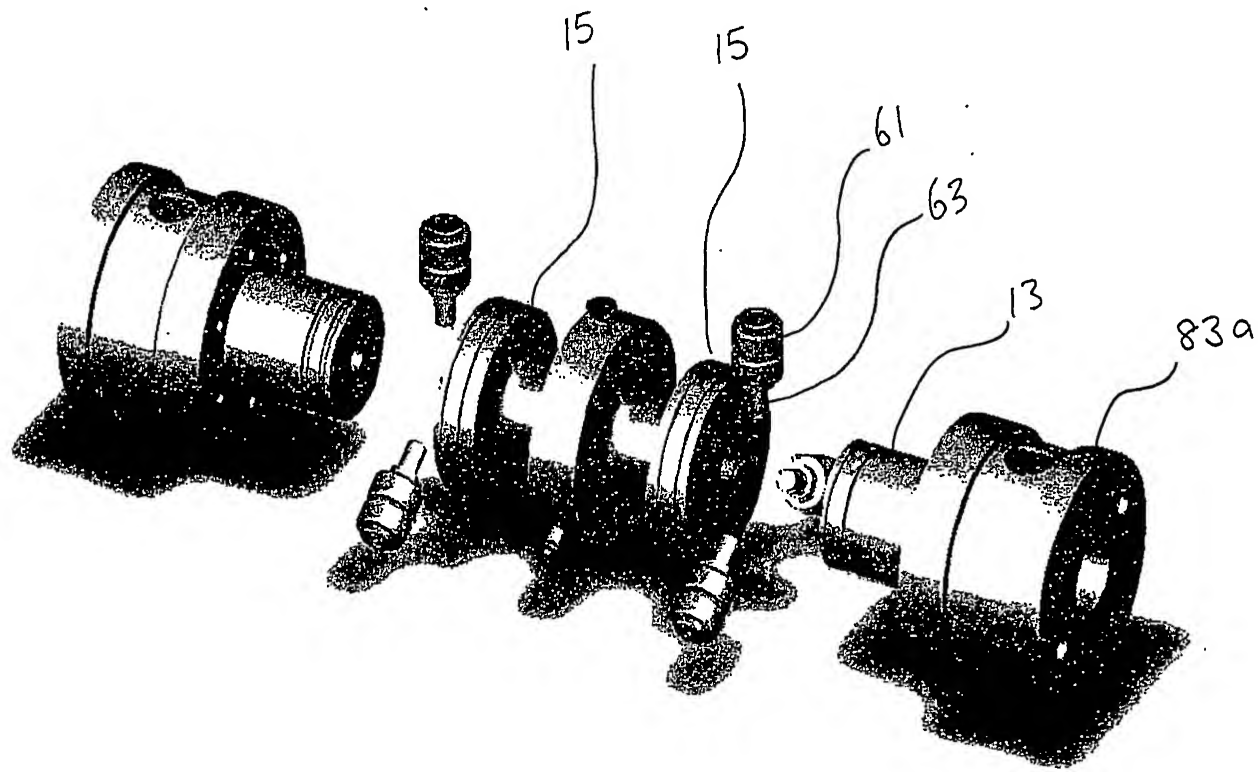


FIG 11

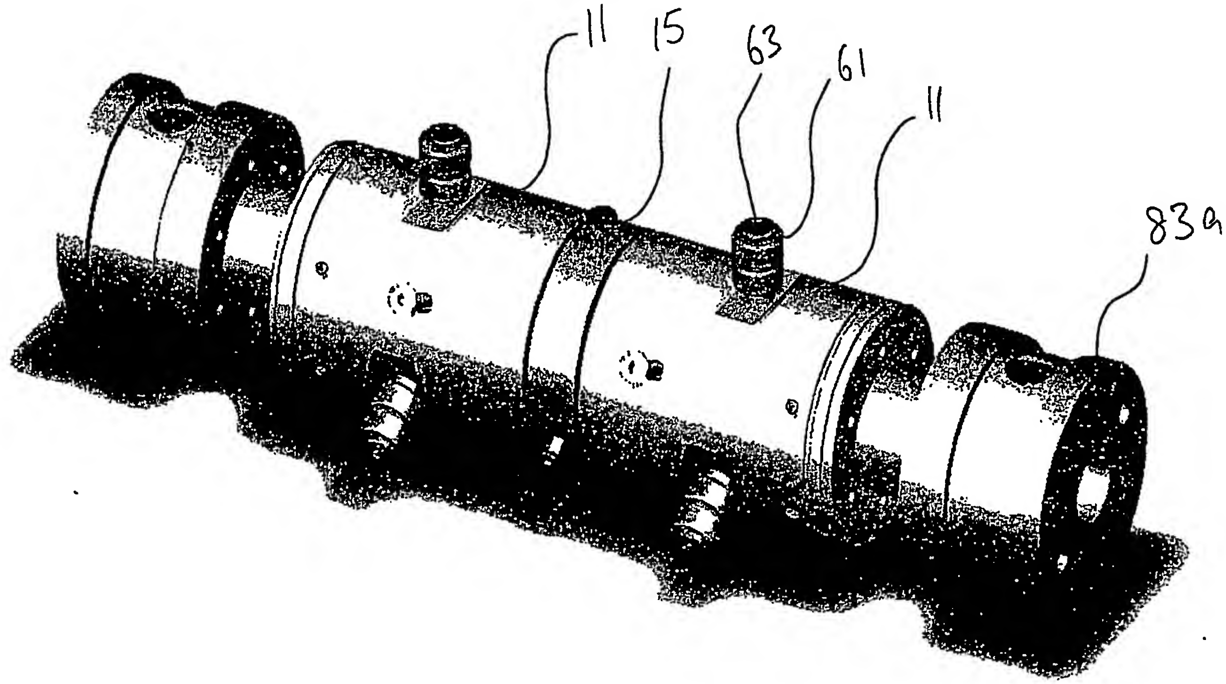


FIG 12

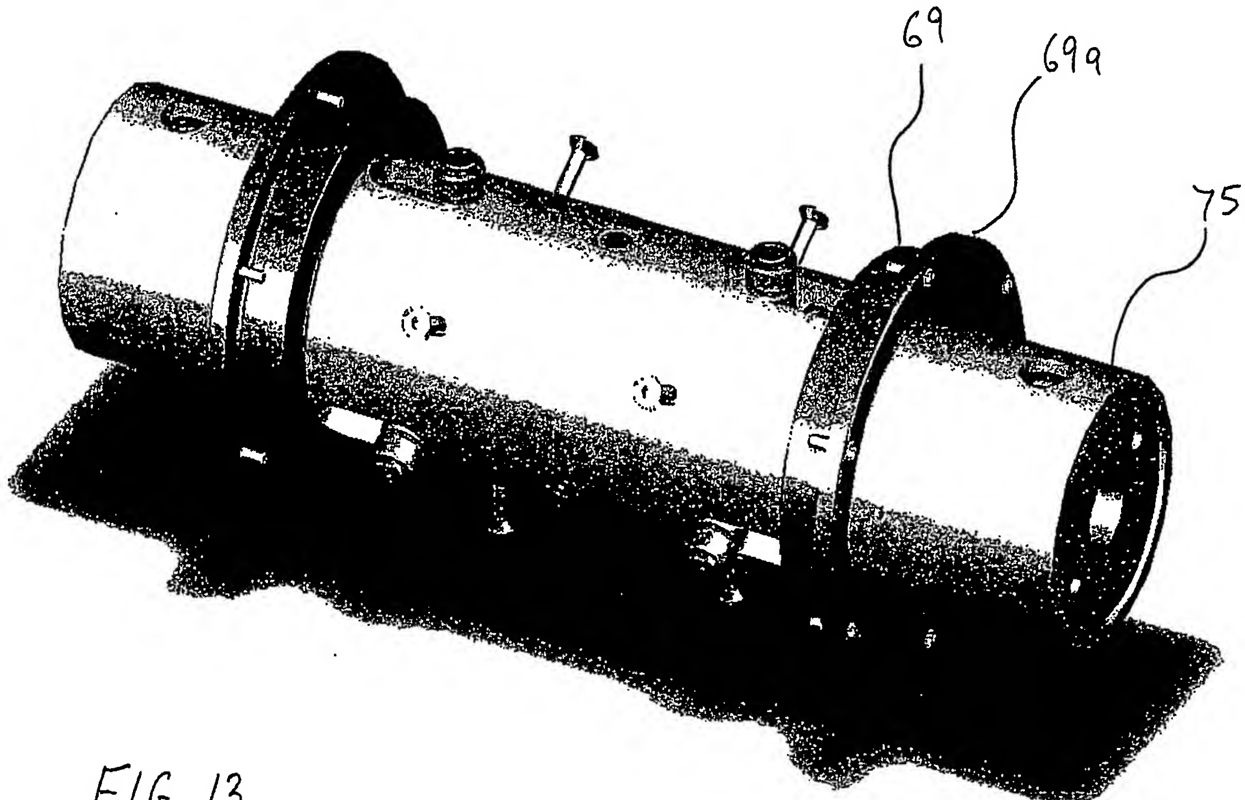


FIG 13

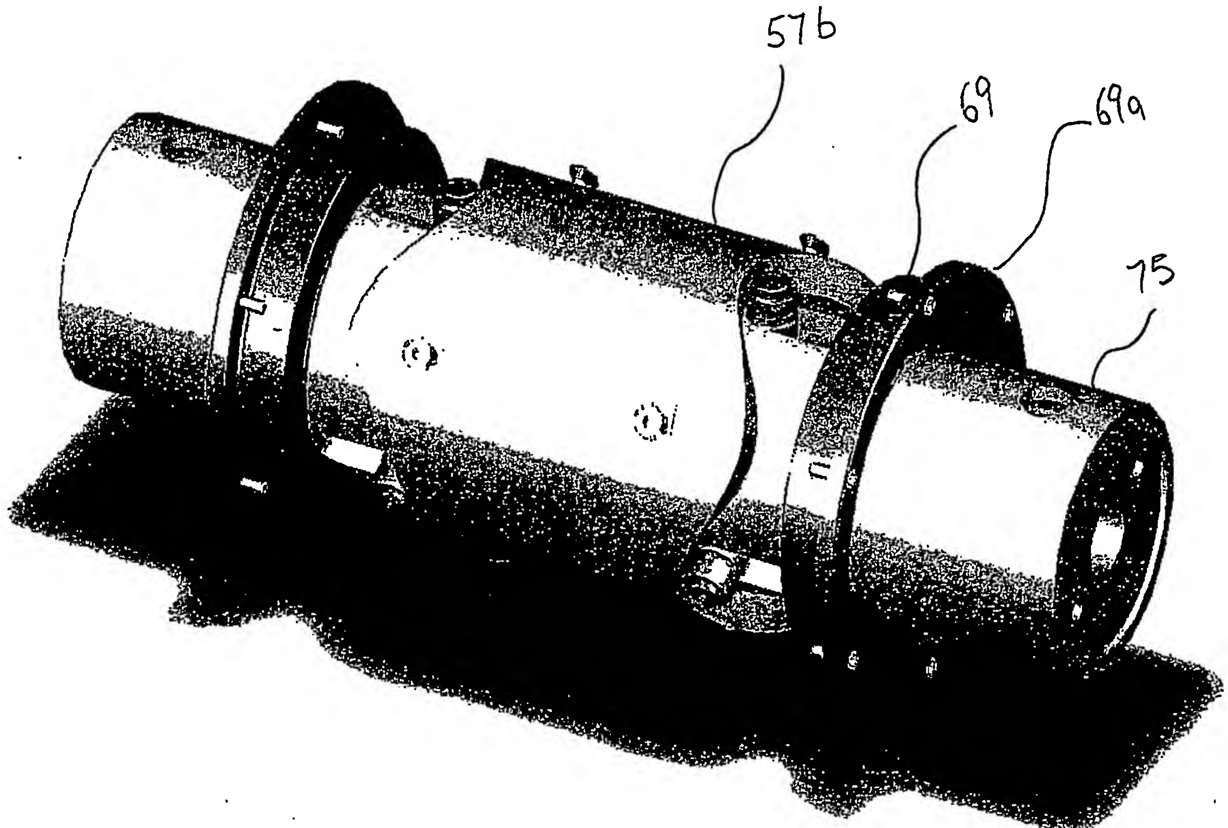


FIG 14

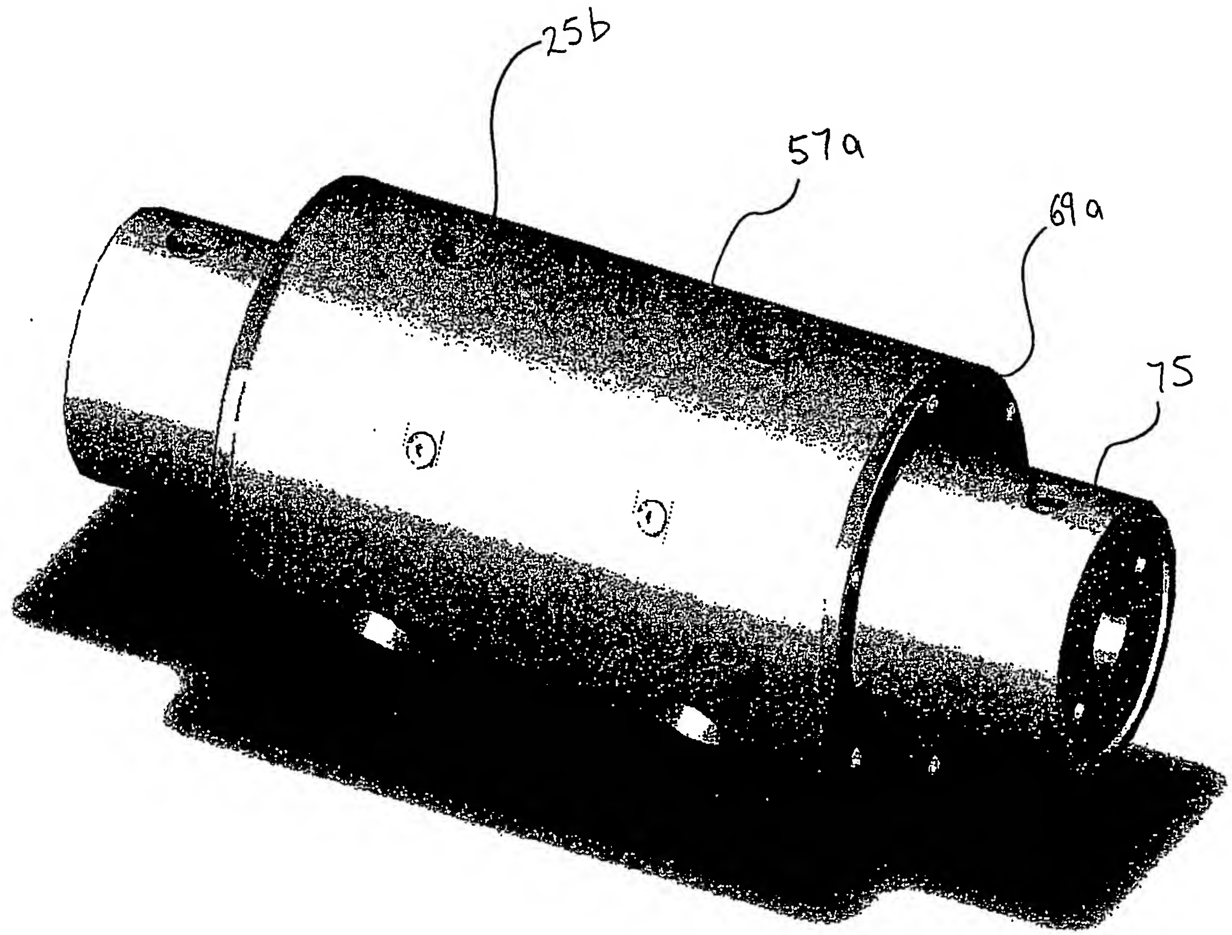


FIG 15

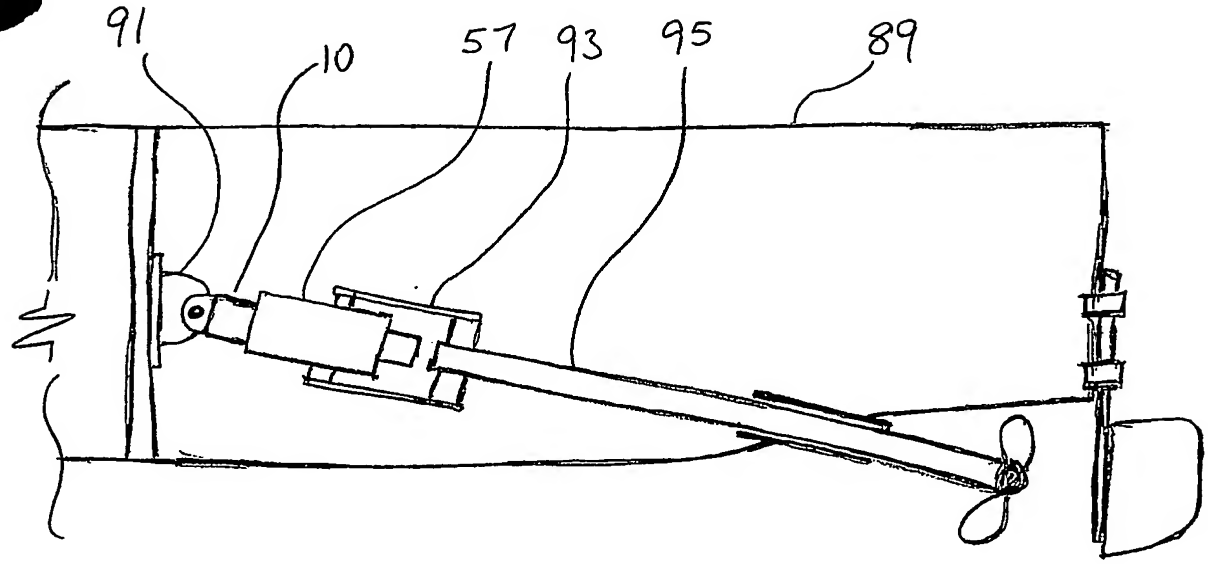


FIG 16

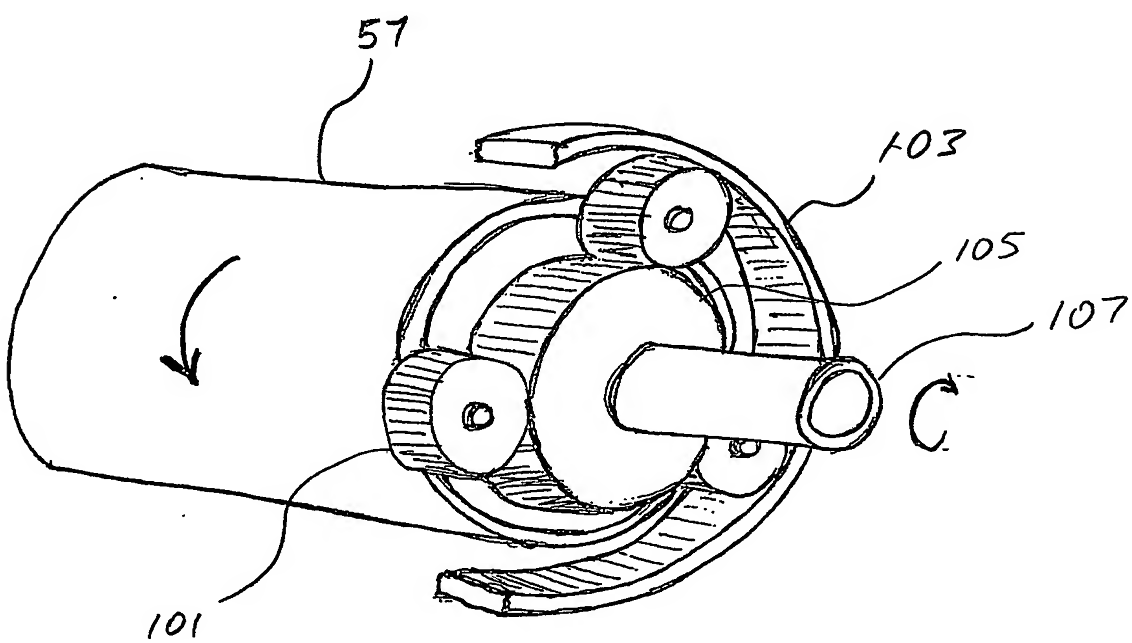


FIG 17

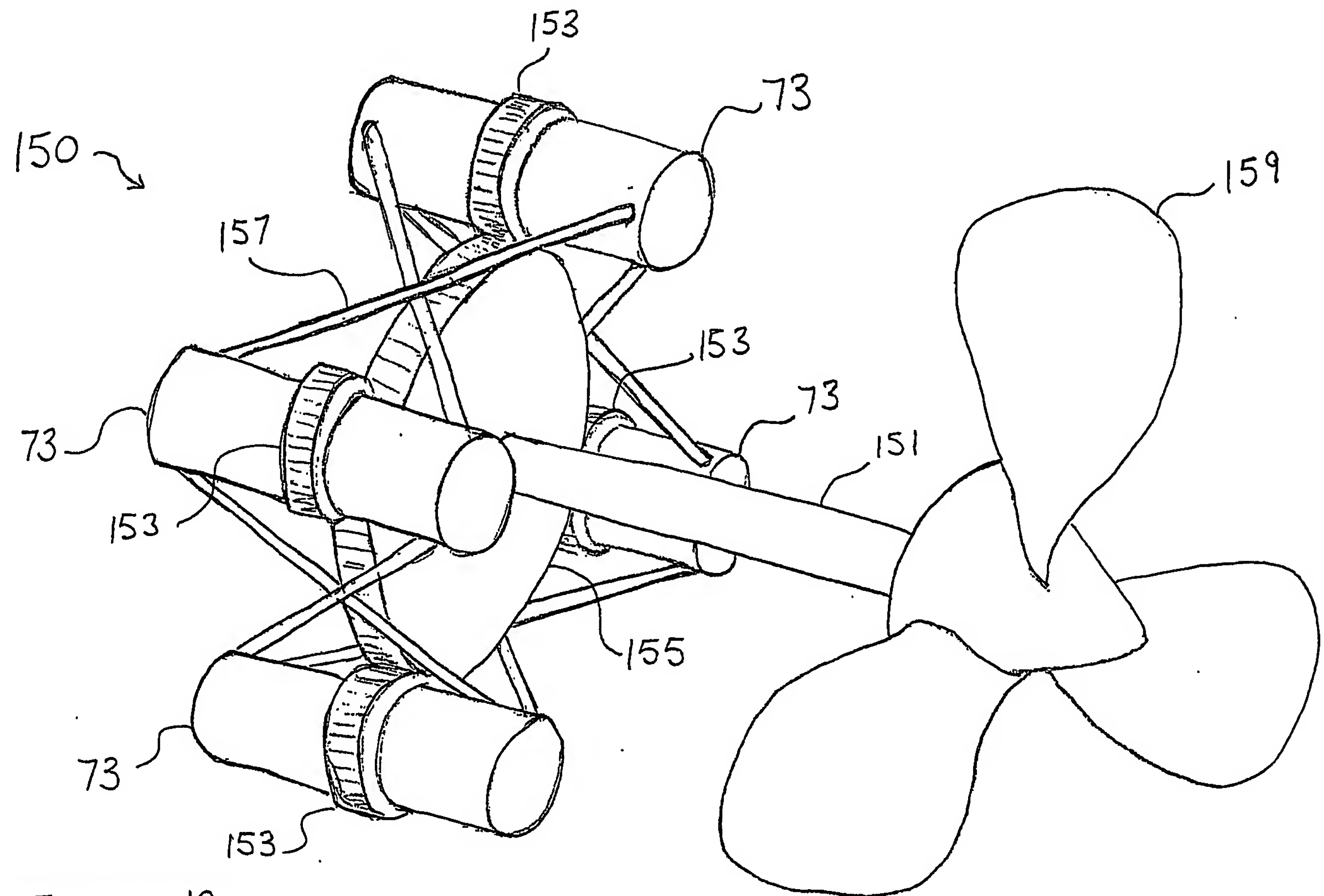


FIGURE 18

5 3 5 3 5 1